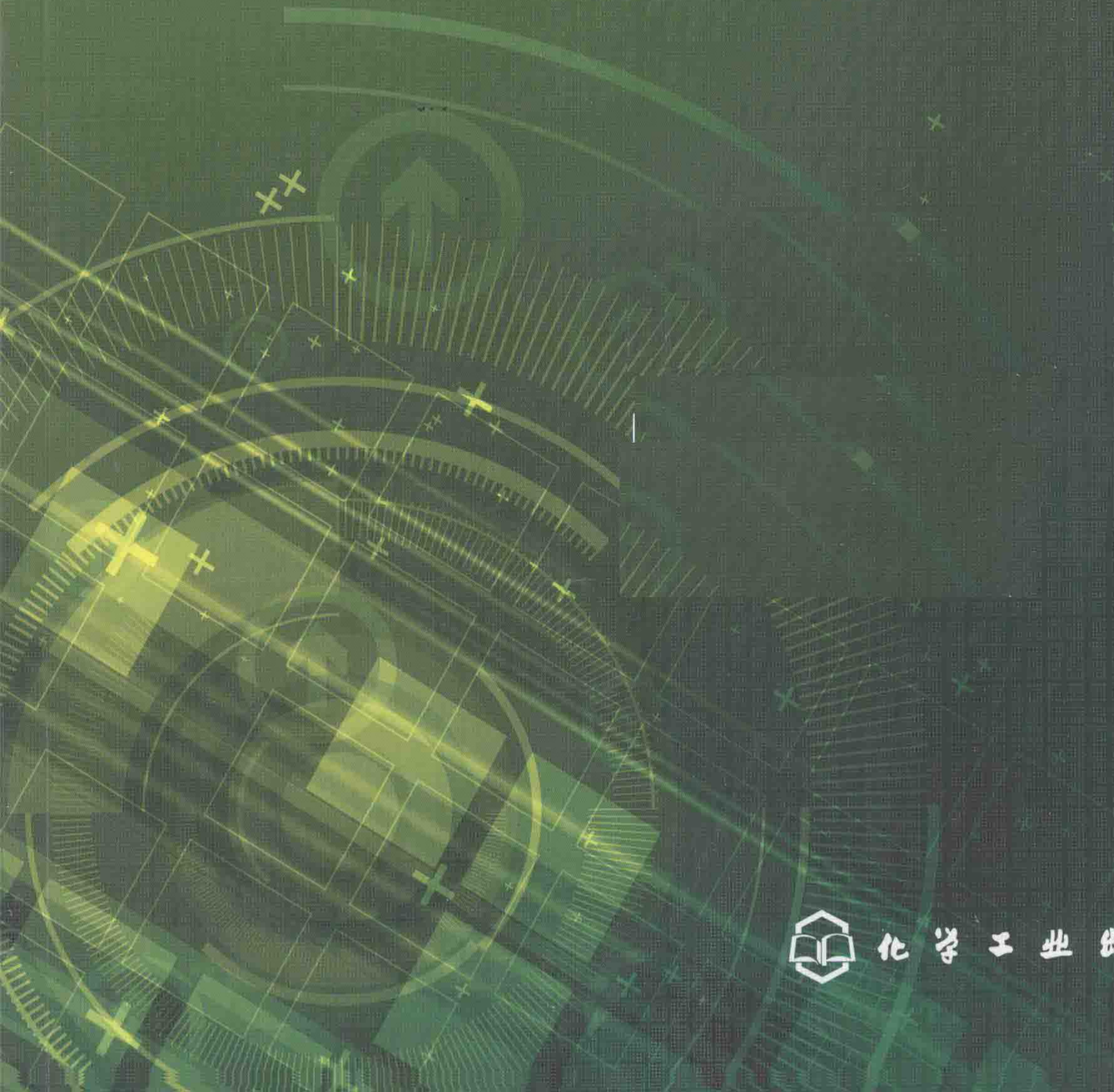
高等学校教材

过程装备与控制工程专业英语

魏新利　周邵萍　主编



化学工业出版社

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·北京·

本教材共分为六个部分（PART），每个部分5个单元（Unit），共30个单元，每个单元由一篇课文和一篇阅读材料组成。另外有1个附录“专业英语阅读指导”和词汇总表。阅读材料提供与课文相应的背景知识或是课文的续篇，以进一步拓宽课文内容。根据课文与阅读材料的内容，配有相应的练习题、注释和词汇表。课文与阅读材料共计60篇，均选自原版英文教科书、科技报告、著作、专业期刊等。体裁较广，基本覆盖了过程装备与控制工程专业的相关内容。

每篇课文后边的词汇与练习，主要是帮助读者在专业内容方面进行英语阅读的训练。附录的“专业英语阅读指导”，主要针对专业英语的语言特点和表达习惯，用于指导读者对专业英语的阅读和理解。

本教材可供过程装备与控制工程及相关专业本科生使用，也可作为同等程度的专业技术人员使用。

图书在版编目(CIP)数据

过程装备与控制工程专业英语/魏新利，周邵萍主编．
北京：化学工业出版社，2014.12
高等学校教材
ISBN 978-7-122-21996-1

Ⅰ．①过…　Ⅱ．①魏…②周…　Ⅲ．①化工过程-化
工设备-英语-高等学校-教材②化工过程-过程控制-英语-
高等学校-教材　Ⅳ．①H31

中国版本图书馆CIP数据核字（2014）第231792号

责任编辑：程树珍　李玉晖　　装帧设计：史利平
责任校对：边　涛

出版发行：化学工业出版社（北京市东城区青年湖南街13号　邮政编码100011）
印　　装：三河市延风印装厂
787mm×1092mm　1/16　印张13¼　字数326千字　2015年3月北京第1版第1次印刷

购书咨询：010-64518888（传真：010-64519686）　售后服务：010-64518899
网　　址：http://www.cip.com.cn
凡购买本书，如有缺损质量问题，本社销售中心负责调换。

定　　价：30.00元

前言

Preface

专业英语的学习，主要是提高学生正确、快速地阅读英语科技文献的能力，初步学会专业英语的表达与写作方法，掌握一定数量的科技词汇及其习惯用法，了解专业英语的特点，提高学生科技和专业英语的阅读能力。

本教材包括过程装备与控制工程专业英语词汇和相当数量的常用科技词汇，词汇复现率较高。 练习主要以英译汉、汉译英、用英语回答问题及写出课文或某一段落的摘要等主观题型为主，目的是提高学生用英语书面表达科技信息的能力。

本教材共分为六个部分（PART），每个部分5个单元（Unit），共30个单元，每个单元由一篇课文和一篇阅读材料组成。 另外有1个附录“专业英语阅读指导”和词汇总表。 阅读材料提供与课文相应的背景知识或是课文的续篇，以进一步拓宽课文内容。 根据课文与阅读材料的内容，配有相应的练习题、注释和词汇表。 课文与阅读材料共计60篇，均选自原版英文教科书、科技报告、著作、专业期刊等。 体裁较广，基本覆盖了过程装备与控制工程专业的相关内容。 其中：

PART Ⅰ为工程力学概论，包括材料力学导论、正应力和应变、切应力和应变、刚体动力学、刚体静力学等基本概念；

PART Ⅱ为金属材料概论，包括金属、材料性能、材料加工、钢的内部结构、金属材料腐蚀等基本概念；

PART Ⅲ为过程原理概论，包括食品加工过程的传递现象、热量传递、质量传递、化学反应工程、化学工程等基本概念；

PART Ⅳ为过程装备概论，包括压力容器及部件、蒸馏设备、换热设备、吸收设备、反应器等单元设备简介；

PART Ⅴ为过程机械概论，包括泵、压缩机、机械密封、固液分离器等过程机器简介以及振动等基本概念；

PART Ⅵ为过程控制概论，包括过程控制导论、基本控制理论、控制回路设备与技术、控制模式、工业过程控制系统等基本概念；

每篇课文后边的词汇与练习，主要是帮助读者在专业内容方面进行英语阅读的训练。 附录的“专业英语阅读指导”，主要针对专业英

语的语言特点和表达习惯，用于指导读者对专业英语的阅读和理解。书后附有总词汇表。

本教材由郑州大学魏新利和华东理工大学周邵萍主编。其中第Ⅰ～第Ⅳ部分分别由郑州大学的吴金星、薛冰、赵金辉、刘华东老师编写；第Ⅴ和第Ⅵ部分由华东理工大学的周邵萍老师编写，编写过程中得到了夏春明等老师的帮助。附录由吴金星编写，全书由郑州大学魏新利统稿。华东理工大学涂善东教授审阅了全部书稿，对书稿提出了许多很好的修改建议，其中大部分修改建议已经采纳，个别建议由于时间紧迫未能采纳，对涂善东教授为本书稿做出的贡献表示衷心感谢。在编写过程中还得到了教育部过程装备与控制工程专业教学指导分委员会、郑州大学、华东理工大学以及化学工业出版社的大力支持。在此谨致衷心感谢！

由于本过程装备与控制工程专业涉及领域宽，学科面广，限于编者水平，不妥之处在所难免，我们真诚希望使用本书的广大师生提出宝贵意见，使本书在使用过程中不断得到改进。

编者

2014 年 8 月

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PART Ⅰ

ENGINEERING MECHANICS

Unit 1 Introduction to Mechanics of Materials

Mechanics of materials is a branch of applied mechanics that deals with the behavior of solid bodies subjected to various types of loading. Other names for this field of study are strength of materials and mechanics of deformable bodies. The solid bodies considered in this unit include bars with axial loads, shafts in torsion, beams in bending, and columns in compression.

The principal objective of mechanics of materials is to determine the stresses, strains, and displacements in structures and their components due to the loads acting on them. If we can find these quantities for all values of the loads up to the loads that cause failure, we will have a complete picture of the mechanical behavior of these structures. ①

An understanding of mechanical behavior is essential for the safe design of all types of structures, whether airplanes and antennas, buildings and bridges, machines and motors, or ships and spacecraft. That is why mechanics of materials is a basic subject in so many engineering fields. Statics and dynamics are also essential, but those subjects deal primarily with the forces and motions associated with particles and rigid bodies. In mechanics of materials we go one step further by examining the stresses and strains inside real bodies, that is, bodies of finite dimension that deform under loads. ② To determine the stresses and strains, we use the physical properties of the materials as well as numerous theoretical laws and concepts.

Theoretical analyses and experimental results have equally important roles in mechanics of materials. We use theories to derive formulas and equations for predicting mechanical behavior, but these expressions can not be used in practical design unless the physical properties of the materials are known. Such properties are available only after careful experiments have been carried out in the laboratory. Furthermore, not all practical problems are amenable to theoretical analysis alone, and in such cases physical testing is a necessity.

The historical development of mechanics of materials is a fascinating blend of both theory and experiment—theory has pointed the way to useful results in some instances, and experiment has done so in others. ③ Such famous persons as Leonardo da Vinci④ (1452—

1519）and Galileo Galilei⑤（1564-1642）performed experiments to determine the strength of wires，bars，and beams，although they did not develop adequate theories（by today’s standards）to explain their test results. By contrast，the famous mathematician Leonhard Euler（1707-1783）developed the mathematical theory of columns and calculated the critical load of a column in 1744，long before any experimental evidence existed to show the significance of his result. Without appropriate tests to back up his theories，Euler’s results remained unused for over a hundred years，although today they are basis for the design and analysis of most columns.

When studying mechanics of materials，you will find that your efforts are divided naturally into two parts：first，understanding the logical development of the concepts，and second，applying those concepts to practical situations. Some of the problems are numerical in character，and others are symbolic（or algebraic）.

An advantage of numerical problems is that the magnitudes of all quantities are evident at every stage of the calculations，thus providing an opportunity to judge whether the values are reasonable or not. The principal advantage of symbolic problems is that they lead to general-purpose formulas. A formula displays the variables that affect the final results；for instance，a quantity may actually cancel out of the solution，a fact that would not be evident from a numerical solution. Also，an algebraic solution shows the manner in which each variable affects the results，as when one variable appears in the numerator and another appears in the denominator. Furthermore，a symbolic solution provides the opportunity to check the dimensions at every stage of the work. Finally，the most important reason for solving algebraically is to obtain a general formula that can be used for many different problems. In contrast，a numerical solution applies to only one set of circumstances. Because engineers must be adept at both kinds of solution，you will find a mixture of numeric and symbolic problems throughout this unit.

Numerical problems require that you work with specific units of measurement. In keeping with current engineering practice，this unit utilizes both the International System of Units（SI）and the U. S. Customary System（USCS）.

（Selected from：James MGere；Mechanics of Materials；
Books/Cole Publishing Company；2001）

Words and Expressions

1. mechanics	[mi'kæniks]	*n*. 力学（用作单数），机械学（用作单数）
2. deformable	[ˌdi'fɔːməbl]	*adj*. 可变形的
3. torsion	['tɔrʃən]	*n*. 扭转，扭曲，扭力
4. strain	[strein]	*n*. 张力，拉紧，应变　*vi*. 拉紧，使变形
5. displacement	[dis'pleism(ə)nt]	*n*. 取代，位移
6. column	['kɔləm]	*n*. 圆柱，柱形物，塔
7. components	[kəm'pəunənt]	*adj*. 组成的，构成的　*n*. 成分，组件，构件

8. antennas	[æn'tenə]	*n*. 天线
9. derive	[di'raiv]	*vt*. 源于，得自 *vi*. 起源
10. available	[ə'veləbl]	*adj*. 有效的，可得的，可利用的，空闲的
11. amenable	[ə'minəbl]	*adj*. 有责任的，应服从的，有义务的，顺从的
12. symbolic	[sim'bɔlik]	*adj*. 象征的，符号的，使用符号的
13. denominator	[di'nɔmineitə]	*n*. [数] 分母，命名
14. conversion	[kən'və:ʒn]	*n*. 转换，变换，改变信仰

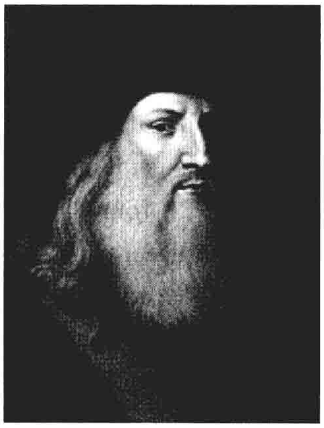
Notes

① 本句可译为："如果能够得到物体从受载到失效的所有与载荷对应的这些物理量（指前述的应力、应变和位移），我们就对物体的力学性能有了一个全面的了解。"

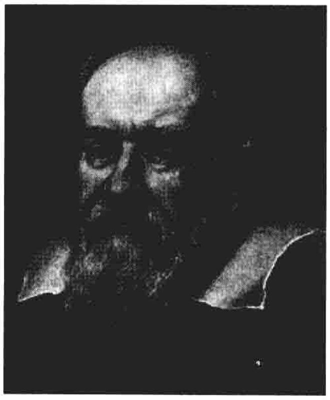
② 本句可译为："在材料力学里，通过考查真实物体（即受载后发生有限变形的物体）内的应力和应变，对其进行进一步的深入研究。"

③ 本句可译为："材料力学的发展历史是理论和实验的有趣结合——在某些情况下理论为得到有价值的结论提供指导，而其他情况下实验同样可以做到。"

④ **Leonardo da Vinci** (15 April, 1452-2 May, 1519) was an Italian Renaissance architect, musician, anatomist, inventor, engineer, sculptor, geometer and painter. He was described as the archetype of the "Renaissance man" and as a universal genius. Leonardo is famous for his masterly paintings, such as The Last Supper and Mona Lisa. He is also known for designing many inventions that anticipated modern technology, although few of these designs were constructed in his lifetime . In addition, he helped advance the study of anatomy, astronomy, and civil engineering. Renaissance humanism saw no mutually exclusive polarities between sciences and arts.



⑤ **Galileo Galilei** (15 February, 1564-8 January, 1642) was born in Pisa, Ducny of Florence, was an Italian physicist, mathematician, astronomer, and philosopher who played a major role in the Scientific Revolution. Galileo has been called the "father of modern observational astronomy," the "father of modern physics," the "father of science" and "the Father of Modern Science. " Stephen Hawking says, "Galileo, perhaps more than any other single person, was responsible for the birth of modern science. "



Exercises

1. Please write an abstract for this text in no more than 200 words.

2. Please translate the third paragraph of the text into Chinese.
3. What is the purpose of research on mechanics of materials?
4. What is the connection between theoretical analyses and experimental results?
5. Please translate the following into English:
   材料力学；载荷；扭转；弯曲；压缩；压力；剪力

Reading Material 1

Introduction to Rest and Motion

Uniformity of nature. If we place a stone in water, it will sink to the bottom; if we place a cork in water, it will rise to the top. These two statements will be admitted to be true not only of stones and corks which have been seen to sink or rise in water but of all stones and corks. Given a piece of stone which has never been placed in water, we feel confident that if we place it in water it will sink. What justification have we for supposing that this new and untried piece of stone will sink in water? We know that millions of pieces of stone have at different times been placed in water; we know that not a single one of these has ever been known to do anything but sink. From this we infer that nature treats all pieces of stone alike when they are placed in water, and so feel confident that a new and untried piece of stone will be treated by the force of nature in the same way as the innumerable pieces of stone of which the behavior has been tested, and hence that it will sink in water. This principle is known as that of the uniformity of nature; what the forces of nature have been found to do once, they will, under similar conditions, do again.

Laws of nature. The principle just stated amounts to saying that the action of nature is governed by certain laws; these we speak of as laws of nature. For instance, if it has been found that every stone which has ever been placed in water has sunk to the bottom, then, as has already been said, the principle of uniformity of nature leads us to suppose that every stone which at any future time is placed in water will sink to the bottom; and we can then announce, as a law of nature, that any stone, place in water, will sink to the bottom.

That part of science which deals with the laws of nature is called natural science. Natural science is divided into two parts, experimental and theoretical. Experimental science tries to discover laws of nature by observing the action of the forces of nature time after time. Theoretical science takes as its material the laws of nature discovered by experimental science, and aims at reducing them, if possible, to simpler forms, and then discovering how to predict from these laws what the action of the forces of nature will be in cases which have not actually been subjected to the test of experiment. For example, experimental science discovers that a stone sinks, that a cork floats, and a number of similar laws. From these theoretical physics arrives at the simple laws of nature which govern all phenomena of sinking or floating, and, going further, shows how these laws enable us to predict, before the experiment has been actually tried, whether a giver body will sink or float. For instance, experimental science can not discover whether a 50, 000-ton ship will float or sink, because no 50, 000-ton ship exists with which to experiment. The naval architect, relying on the uniformity of nature, on the laws of nature determined by experimental science, and on the method of handling these laws taught by theoretical science, may build a 50, 000-ton ship with every confidence that it will behave in the way predicted by theoretical science.

The science of mechanics. The branch of science known as mechanics deals with the motion of bodies in space, and with the forces of nature which cause or tend to cause this motion. The laws of nature which govern the action of these forces and the motion of bodies have long been known, and were reduced to their simplest form by Newton. Thus we may that experimental mechanics is a completed branch of science.

We start form the laws supplied by experimental mechanics, and have to discuss how these laws can be used to predict the motion of bodies, for instance, the falling of bodies to the ground, the firing of projectiles, the motion of the earth and the planets round the sun. An important class of problems which we shall have to discuss will be those in which no motion takes place, the forces of nature which tend to cause motion being so evenly balanced that no motion occurs. Such problems are known as statical.

State of rest. Before we can reason about the motion of a body we have to determine what is meant by a body being at rest. In ordinary language we say that a train is at rest when the cars are not moving over the rails. We know, however, that the train, in common with the rest of the earth, is not actually at rest, but moving round the sun with a great velocity. Again, a fly crawling on the wall of a railway car might in one sense be said to be at rest, if it remained standing on the same spot of the wall. The fly, however, would not actually be at rest; it would share in the motion of the earth round the sun, and the sun would share in the motion of the whole solar system through space.

These instances will show the necessity of attaching a clear and exact meaning to the conceptions of rest and motion. Obviously our statements would have been exact enough if we had said that in the first case the train was at rest relatively to the earth, and that in the second case the fly was at rest relatively to the car.

Frame of reference. Thus we find it necessary, before discussing rest and motion, to introduce the conception of a frame of reference. The earth supplied a frame of reference for the motion of the train, and when a train is not moving over the rails we may say that it is at rest, the earth being taken as frame of reference. So also we could say that the fly was at rest, the car being taken as frame of reference. Obviously any framework, real or imaginary, or any material body, may be taken as a frame of reference, provided that it is rigid, i. e. that it is not itself changing its shape or size.

We may accordingly say that a point is at rest relatively to any frame of reference when the distance of the point from each point of the frame of reference remains unaltered.

Motion relative to frame of reference. Having specified a frame of reference, we can discuss not only rest but also motion relative to the frame of reference. When the train has moved a mile over the tracks we say that it has moved a mile relatively to its frame of reference, the earth. When the fly has crawled from floor to ceiling of the car we say that it has moved, say, eight feet relatively to its frame of reference, the car.

(Selected from: Sir James Jeans Ginn; An elementary treatise on theoretical mechanics, Dover Publications; 2005)

Words and Expressions

1. uniformity	[ju:ni'fɔ:miti]	*n*. 均匀性，一致
2. cork	[kɔ:k]	*n*. 瓶塞，软木塞　*vt*. 用瓶塞塞住
3. justification	[dʒʌstifi'keiʃ(ə)n]	*n*. 理由，辩护
4. untried	[ʌn'traid]	*adj*. 未经实验的，未经检查的
5. innumerable	[i'nju:m(ə)rəb(ə)l]	*adj*. 无数的，数不清的
6. phenomena	[fə'nɔminə]	*n*. 现象（phenomenon 的复数）
7. naval	['neiv(ə)l]	*adj*. 海军的，军舰的
8. crawl	[krɔ:l]	*vi*. 爬行，缓慢地行进
9. imaginary	[i'mædʒin(ə)ri]	*adj*. 虚构的，假想的，想象的，虚数的
10. rigid	['ridʒid]	*adj*. 严格的，僵硬的，坚硬的，精确的，刚性的
11. unaltered	[ʌn'ɔ:ltə(r)d]	*adj*. 不变的，未被改变的，照旧的
12. track	[træk]	*n*. 踪迹　*vt*. 追踪，循路而行　*vi*. 追踪

Unit 2 Normal Stress and Strain

The most fundamental concepts in mechanics of materials are stress and strain. These concepts can be illustrated in their most elementary form by considering a prismatic bar subjected to axial forces. A prismatic bar is a straight structural member having the same cross section throughout its length, and axial force is a load directed along the axis of the member, resulting in either tension or compression in the bar. ① Examples are shown in Fig. 1-1, where the tow bar is a prismatic member in tension and the landing gear strut is a member in compression. Other examples are the member of a bridge truss, connecting rods in automobile engines, spokes of bicycle wheel, columns in buildings, and wing struts in small airplanes.

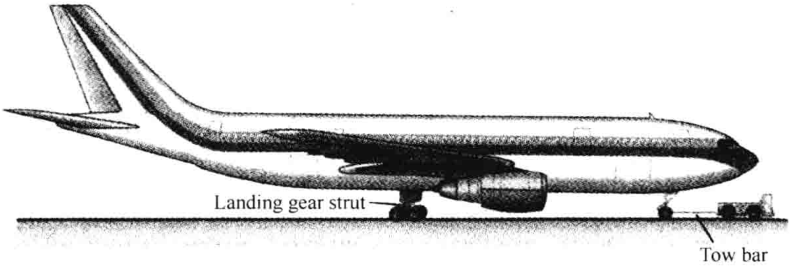


Fig. 1-1 Structural members subjected to axial loads.

(The tow bar is in tension and the landing gear strut is in compression)

For discussion purposes, we will consider the tow bar of Fig. 1-1 and isolate a segment of it as a free body (Fig. 1-2a). When drawing this free-body diagram, we disregard the weight of the bar itself and assume that only active forces are the axial forces P at the ends. Next we consider two views of the bar, the first showing the same bar before the loads are applied (Fig. 1-2b) and the second showing it after the loads are applied (Fig. 1-2c). Note that the original length of the bar is denoted by the letter L, and the increase in length due to the loads is denoted by the Greek letter δ (delta).

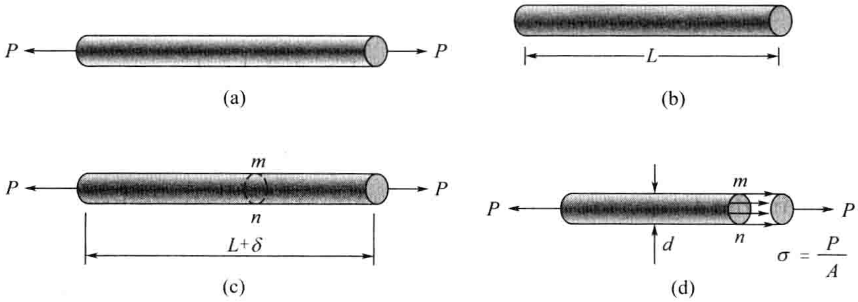


Fig. 1-2 Prismatic bar in tension: (a) Free-body diagram of a segment of the bar; (b) Segment of the bar before loading; (c) Segment of the bar after loading; (d) Normal stresses in the bar

The internal stresses in the bar are exposed if we make an imaginary cut though the bar at section *mn* (Fig. 1-2c). Because this section is taken perpendicular to the longitudinal axis of the bar, it is called a cross section. We now isolate the part of the bar to the left of cross section *mn* as a free body (Fig. 1-2d). At the right-hand end of this free body (section *mn*) we show the action of the removed part of the bar (that is, the part to the right of section *mn*) upon the part that remains. This action consists of a continuously distributed force acting over the entire cross section. The intensity of the force (that is, the force per unit area) is called the stress and is denoted by the Greek letter σ (sigma). Thus, the axial force P acting at the cross section is the resultant of the continuously distributed stresses. (The resultant force is shown with a dashed line in Fig. 1-2d.)

Assuming that the stresses are uniformly distributed over cross section *mn* (Fig. 1-2d), we see that their resultant must be equal to the intensity σ times the cross-sectional area A of the bar. Therefore, we obtain the following expression for the magnitude of the stresses:

$$\sigma = \frac{P}{A} \tag{1-1}$$

This equation gives the intensity of uniform stress in an axially loaded, prismatic bar of arbitrary cross-sectional shape. When the bar is stretched by the force P, the stresses are tensile stresses; if the forces are reversed in direction, causing the bar to be compressed, we obtain compressive stresses. In as much as the stresses act in a direction perpendicular to the cut surface, they are called normal stresses. Thus, normal stresses may be either tensile or compressive.

When a sign convention for normal stresses is required, it is customary to define tensile stresses as positive and compressive stresses as negative. ②

The equation $\sigma = \frac{P}{A}$ is valid only if the stress is uniformly distributed over the cross section of the bar. This condition is realized if the axial force P acts through the centroid of the cross-sectional area, as demonstrated later in this section. When the load P does not act at the centroid, bending of the bar will result, and a more complicated analysis is necessary.

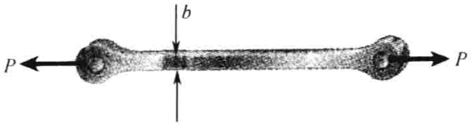


Fig. 1-3 Steel eyebar subjected to tensile loads P

One possibility is illustrated by the eyebar shown in Fig. 1-3. In this instance the loads P are transmitted to the bar by pins that pass through the holes (or eyes) at the ends of the bar. Thus, the force shown in the figure are actually the resultants of bearing pressures between the pins and the eyebar, and the stress distribution around the holes is quite complex. ③ However, as we move away from the ends and toward the middle of the bar, the stress distribution gradually approaches the uniform distribution pictured in Fig. 1-2d.

As already observed, a straight bar will change in length when loaded axially, becoming longer when in tension and shorter when in compression. For instance, consider again the prismatic bar of Fig. 1-2. The elongation δ of this bar（Fig. 1-2c. ）is the cumulative result of the stretching of all elements of the material throughout the volume of the bar. Let us assume that material is the same everywhere in the bar. Then，if we consider half of the bar（length $L/2$），it will have an elongation equal to $\frac{\delta}{2}$，and if we consider one-fourth of the bar，it will have an elongation equal to $\frac{\delta}{4}$. In general，the elongation of a segment is equal to its length divided by the total length L and multiplied by the total elongation δ. Therefore，a unit length of the bar will have an elongation equal to $\frac{1}{L}$ time δ. This quantity is called the elongation per unit length，or strain，and is denoted by the Greek letter ε（epsilon）. We see that strain is given by the equation

$$\varepsilon = \frac{\delta}{L} \tag{1-2}$$

If the bar is in tension，the strain is called a tensile strain，representing an elongation or stretching of the material. If the bar is in compression，the strain is a compressive strain and the bar shortens. Tensile strain is usually taken as positive and compressive strain as negative. The strain ε is called a normal strain because it is associated with normal stresses.

Because normal strain is the ratio of two lengths，it is a dimensionless quantity，that is，it has no units. Therefore，strain is expressed simply as a number，independent of any system of units. Numerical values of strain are usually very small，because bars made of structural materials undergo only small changes in length when loaded.

（Selected from：James MGere；Mechanics of Materials；
Books/Cole Publishing Company；2001）

Words and Expressions

1. fundamental	[fʌndə'ment(ə)l]	*adj*. 基本的，根本的 *n*. 基本原理
2. elementary	[eli'ment(ə)ri]	*adj*. 基本的，初级的
3. prismatic	[priz'mætik]	*adj*. 等截面的，棱柱的
4. perpendicular	[ˌpə:p(ə)n'dikjulə]	*adj*. 垂直的，正交的 *n*. 垂线
5. longitudinal	[ˌlɑndʒə'tudnl]	*adj*. 长度的，纵向的，经线的
6. resultant	[ri'zʌlt(ə)nt]	*n*. 合力，结果 *adj*. 结果的，合成的
7. reversed	[ri'və:s]	*vt*. 颠倒 *adj*. 反面的
8. convention	[kən'venʃ(ə)n]	*n*. 大会，[计] 约定
9. demonstrate	['demənstreit]	*vt*. 证明，展示，论证，证实 *vi*. 示威
10. centroid	['sentrɔid]	*n*. 形心，几何中心
11. transmit	[træns'mɪt]	*vt*. 传输，传播，传达 *vi*. 传输，发射信号
12. elongation	[i:lɔŋ'geiʃ(ə)n]	*n*. 伸长，延伸率
13. cumulative	['kju:mjulətiv]	*adj*. 累积的
14. homogeneous	[ˌhomə'dʒiniəs]	*adj*. 均匀的，[数] 齐次的，同种的